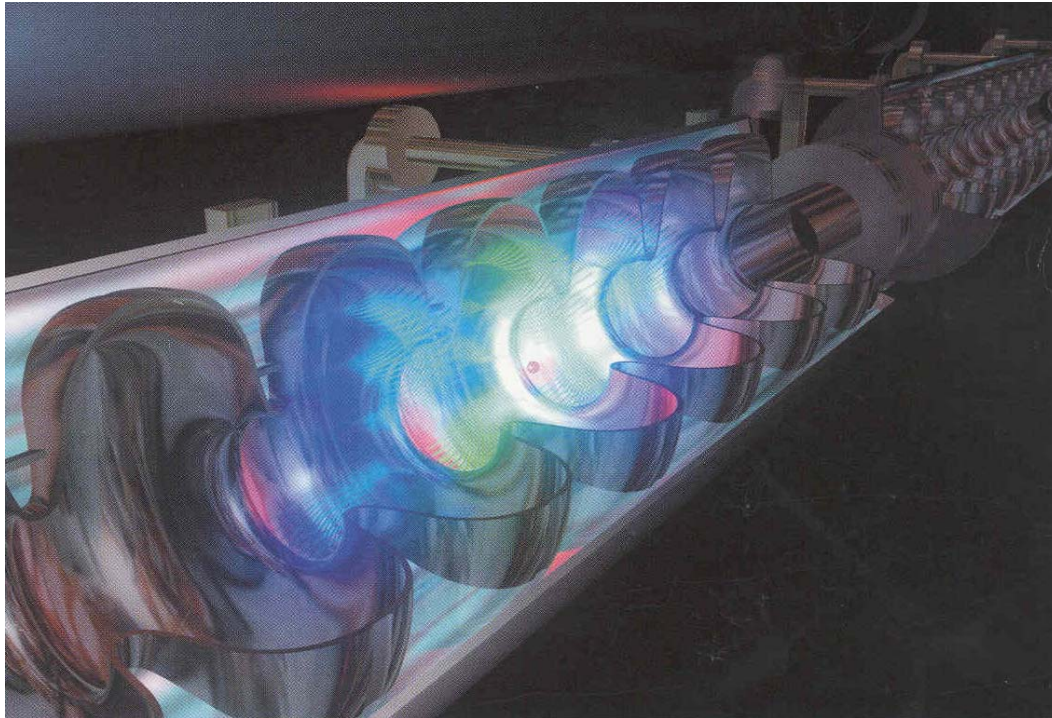


# FERMILAB/NICADD PHOTOINJECTOR LABORATORY



H. Julia Brito  
SIST Program  
Tuesday, August 6, 2002

# PERSONAL BACKGROUND



- Undergraduate at The University of Texas in Austin
- Mechanical Engineering
- Concentration in Biomedical Engineering

# TEMP HOME @ FERMI

- Location
  - A- Zero
  - Beams Division
  - Research and Development lab
- Family
  - DESY = Deutsches Elektronen-Synchrotron (Germany)
  - NICADD = Northern Illinois Center for Accelerator  
Detector and Development
  - LBNL = Lawrence Berkeley National Laboratory
  - University of Rochester

# OUTLINE

- Brief tour of A0 Photoinjector beam line
- Short discussion of work with diagnostic apparatus
- Concise summary of future goals
  - Photoinjector lab
  - Personal

6-CELL CAPTURE CHAMBER

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716 4150

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2818 3868

2819 3869

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# KLYSTRON FOR PHOTO-CATHODE GUN

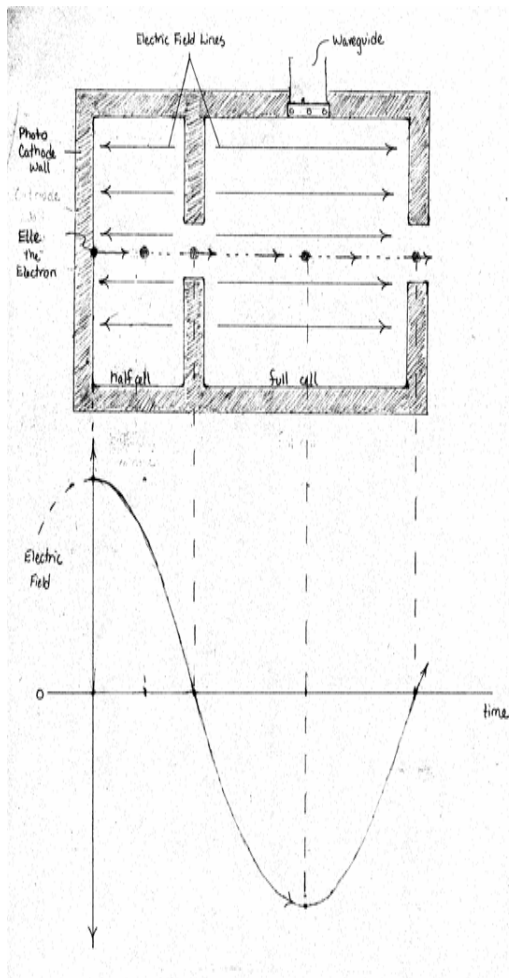


- Output power = 3 MW
- Located outside of beam line cave
- Radio Frequency (RF) waves @ 1.3 GHz travel via a waveguide—minimal losses for higher frequencies

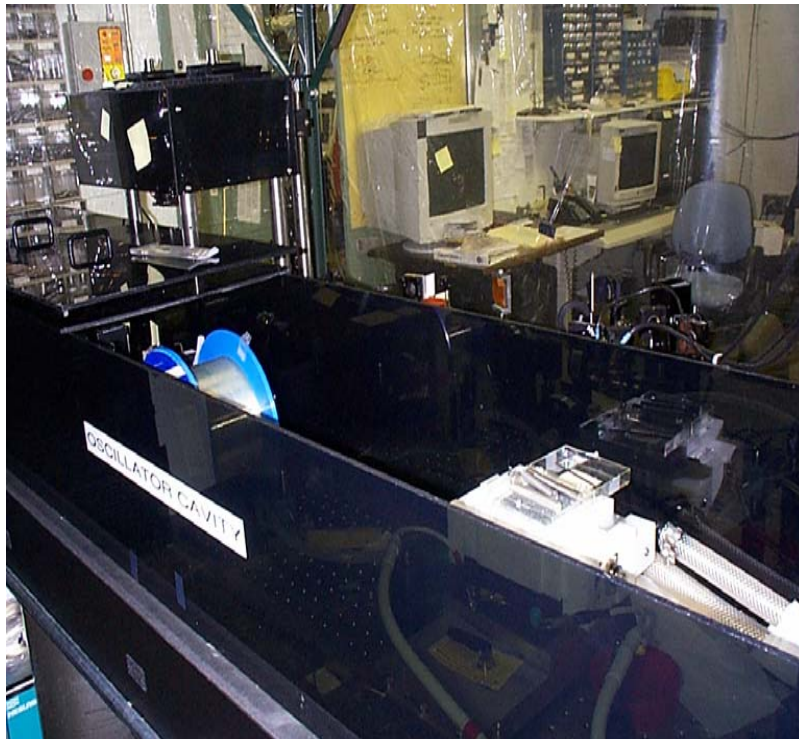


# ENTERING THE CAVE

- RF waves produce electric field in 1.5 cell cavity
- Phase timing is crucial for electrons produced by cathode prep chamber to be accelerated
- Solenoids encircle the cathode gun for electron compression and focus
- Something needed to initially pick off electrons



# CLASS IV LASER



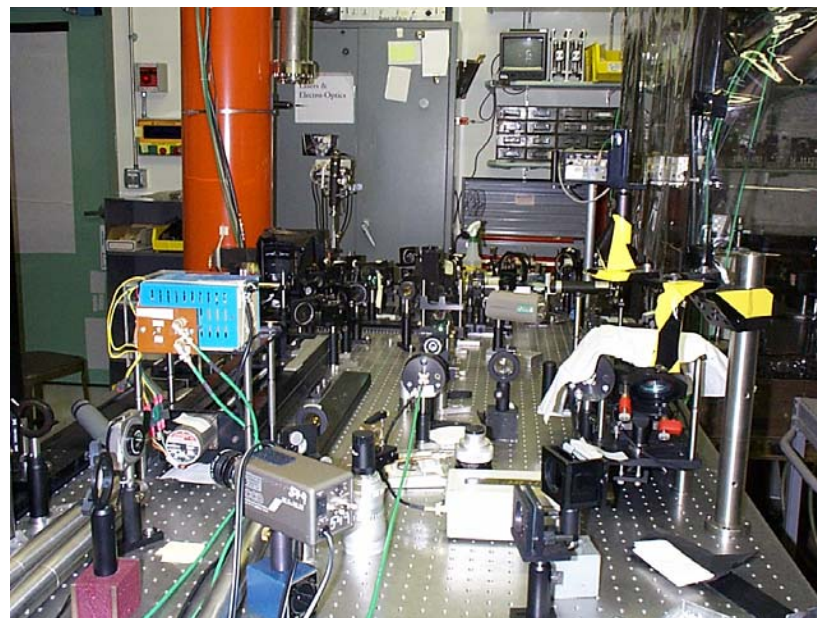
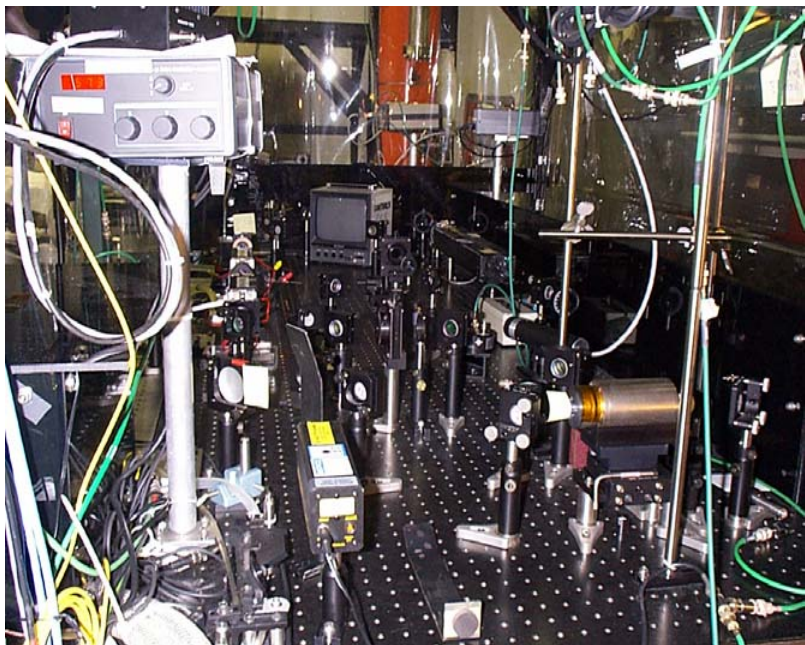
- Laser beam is created in oscillator cavity
- Many components, more things to go wrong
- Problems are not-so-obvious (lamp strike failure)





# INFRARED TO ULTRAVIOLET LIGHT

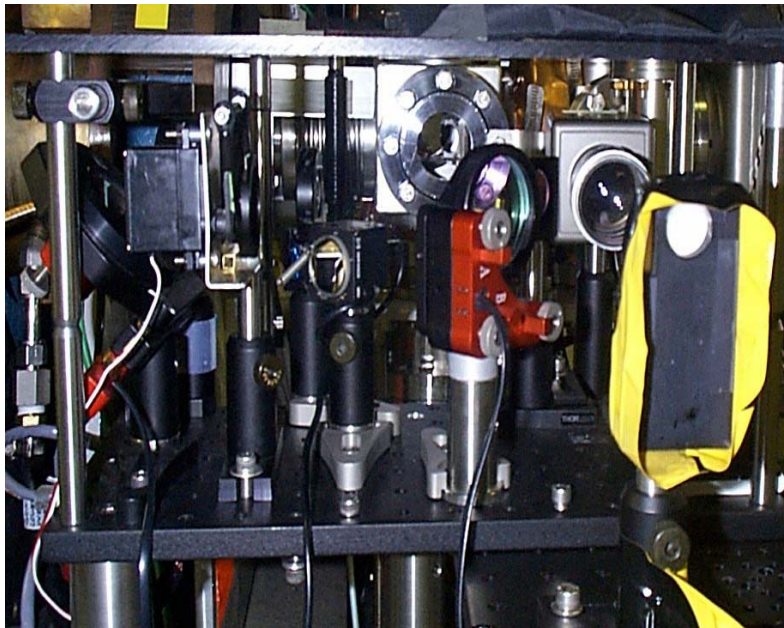
Multi-pass stages used to amplify energy of the laser



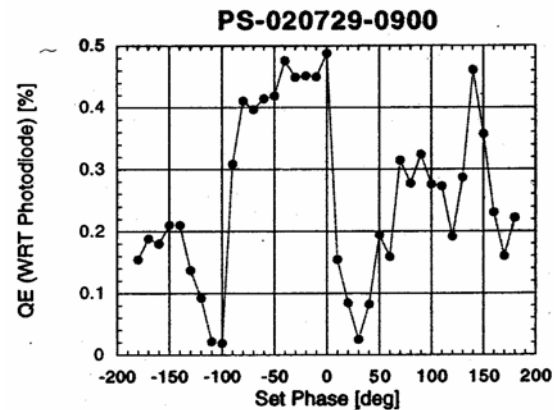
IR is converted to UV via doubling crystals and is guided into the cave

# LASER ENTERS THE BEAM LINE

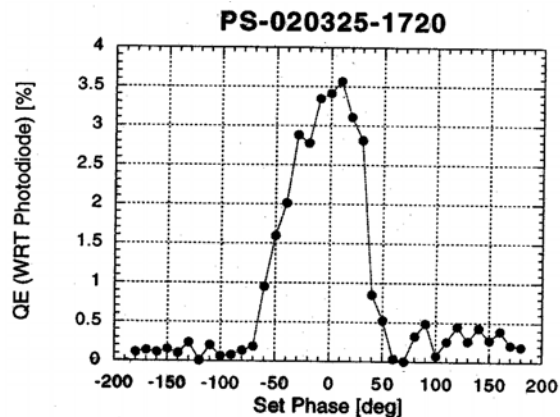
Quantum Efficiency = # of electrons / photon



Laser optics in cave  
(Remote-control Iris)



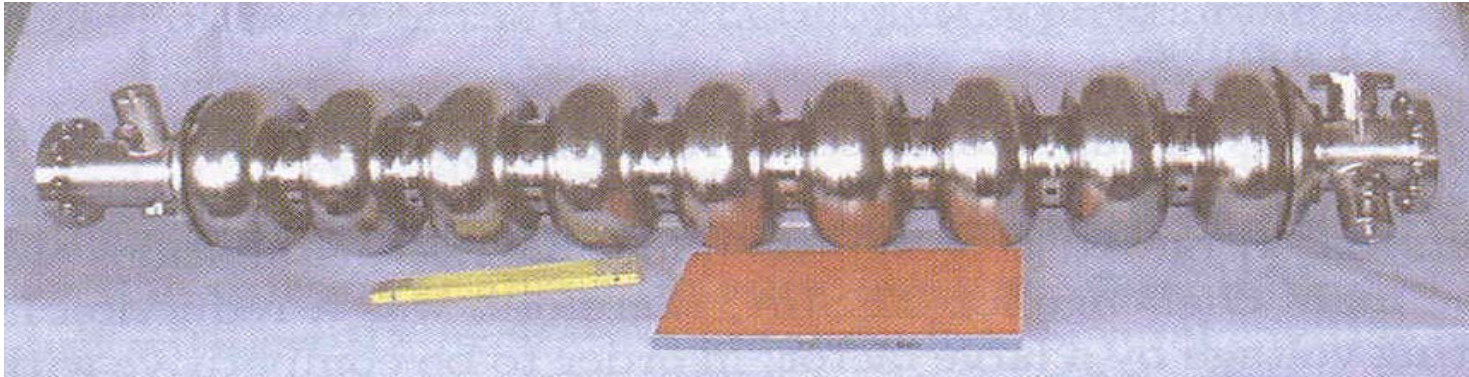
Bad phase  
scan



Good phase  
scan

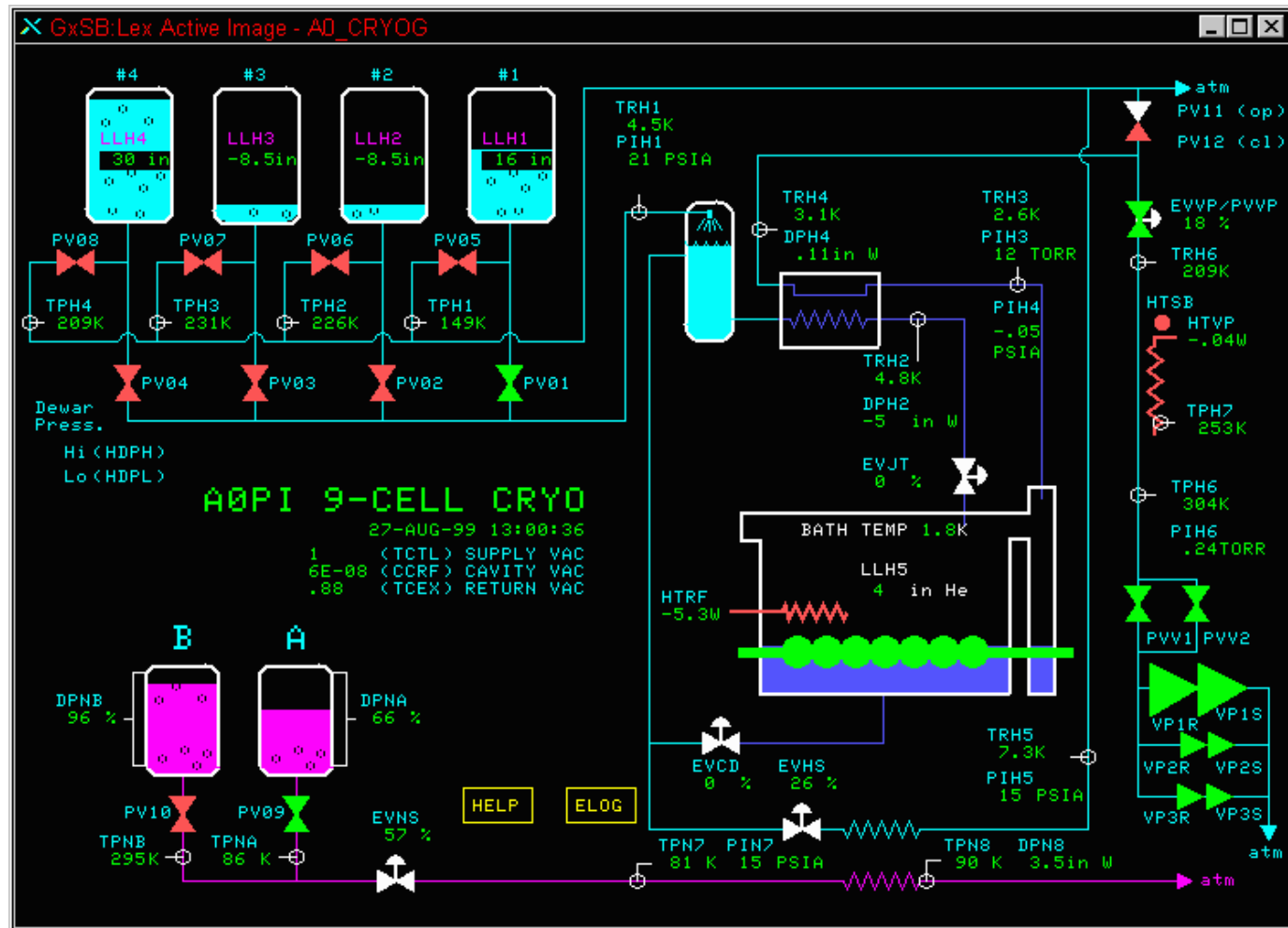


# NINE CELL SUPER-CONDUCTING CAVITY



- \*Each cell progressively steps up the acceleration of the electrons
- \*Energy of the electrons increases from  $\sim 4$  MeV to  $\sim 17$  MeV

# CRYOGENIC MONITOR OF 9 - CELL



# MAGNETS

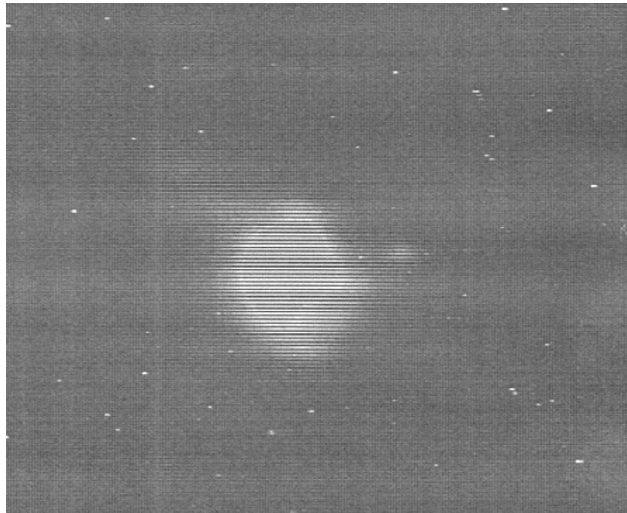
- Dipole magnets: used for steering
- Quadrupole magnets: used for focusing; focuses in the transverse plane i.e. focuses in dimension of space
- Chicane: consists of 4 dipole magnets; steers beam down, straight, up, & straight again; focuses in the longitudinal plane i.e. focuses in dimension of time





# END OF THE BEAM LINE

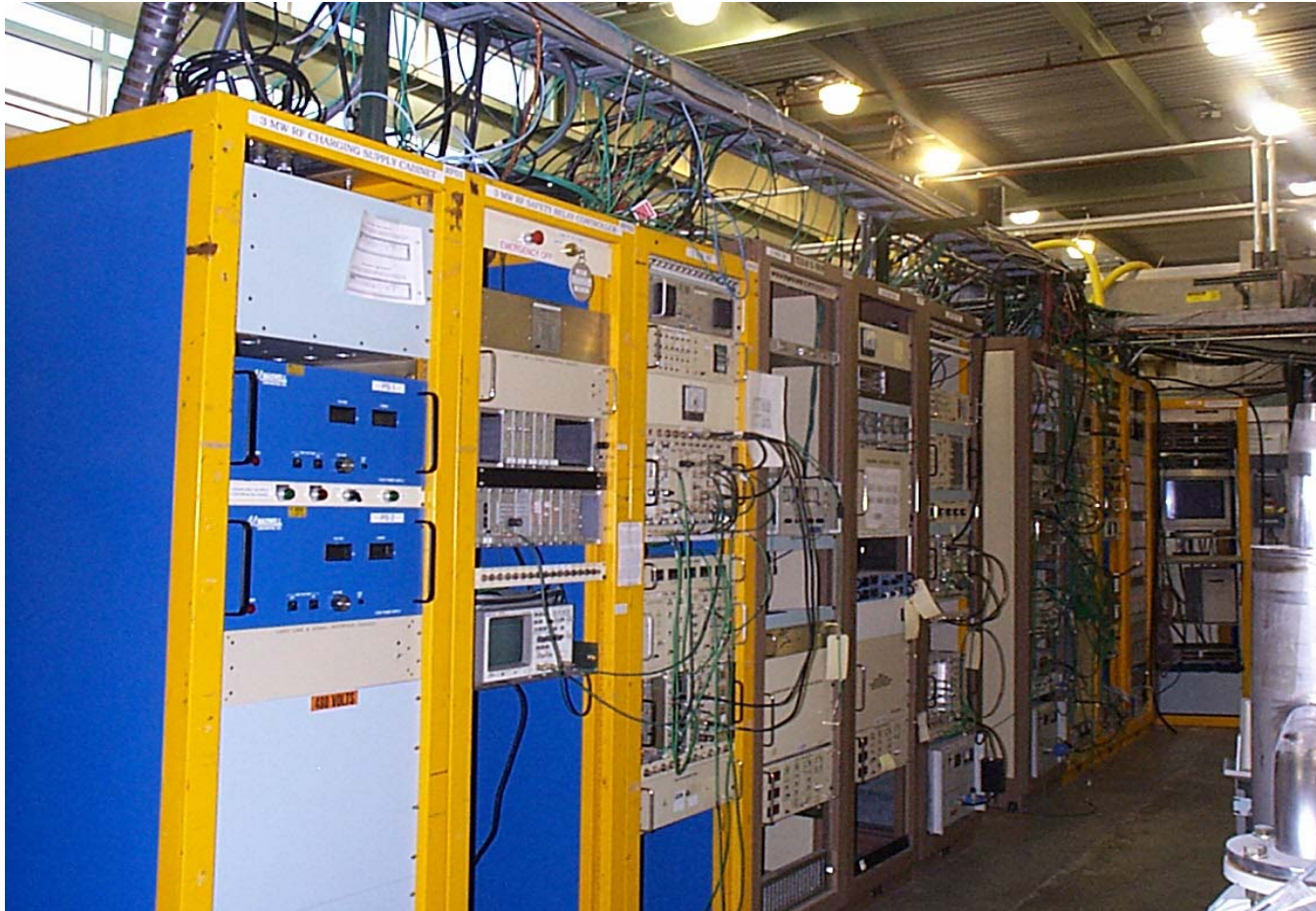
Spectrometer = magnet used to measure the energy at the end of the beam line



$$\text{Total Energy} = \sqrt{(1.54 * I_{\text{spec}})^2 + 0.511^2}$$

|        |       |                    |   |           |   |        |
|--------|-------|--------------------|---|-----------|---|--------|
| _MULT_ | 3.000 | MULT CONTROLLER    | ! | 3.000     | _ | N/A    |
| SOLMN  | 1.000 | SOLENOID MAIN      | * | 179.999   | s | A      |
| SOLEUC | 1.000 | SOLENOID BUCKING   | * | 189.998   | s | A      |
| SOLSEC | 1.000 | SOLENOID SECONDARY | * | 180.003   | s | A      |
| PSPECT | 0.200 | SPECTROMETER PS    | * | 9.496     | s | A      |
| CAMCTL | 1.000 | AVMS CNTRL         | * | undefined | s | ... EN |
| FCUPX2 | 1.000 | ACT#1 FCUPX2       | * | undefined | s | ...OUT |
| FLAGX2 | 1.000 | ACT#2 FLAGX2       | * | undefined | s | ...OUT |
| FLAGX3 | 1.000 | ACT#3 FLAGX3       | * | undefined | s | ...OUT |

# TURNING ON!



# DIAGNOSTICS

- A-Zero Control Room
  - Parameter pages
  - Oscilloscope readings
  - Data acquisition
- Cameras measure transverse bunch profile
- Interferometer measures longitudinal bunch length



# INTERFEROMETER @ XL4

Best approach would be to work without windows  
i.e. have the interferometer be a part of the beam line

However this type of interferometer would:

- \*be hard to align

- \*cost ~\$50,000

Solution:

Insert flag in beam line @  $45^\circ$  angle and design  
a customized viewport

1.) ALL WELDS TO BE VACUUM LEAK TIGHT.  
 2.) LEAK TEST: NO LEAK SHALL BE DETECTABLE ON THE MOST SENSITIVE SCALE OF A HELIUM LEAK DETECTOR WITH A MINIMUM SENSITIVITY OF 10<sup>-9</sup> ATM.CO/SEC.

|   |            |                           |   |
|---|------------|---------------------------|---|
| 3 | F338000    | MDC NON-ROTATABLE CONFLAT | 1 |
| 2 | -----      | 304 STN. STL. TUBE        | 1 |
| 1 | 11466-13-M | CERAMASEAL CRYSTAL QUARTZ | 1 |

PHOTO INTERIOR OF RF GUN

TESLA  
 2782,000-MB

- Crystalline quartz window
- Stainless steel recessed tube and flange
- Vacuum tight conditions





# INTERFEROMETER DESIGN

Designer:  
Uwe Happek  
@ The Univ.  
of Georgia

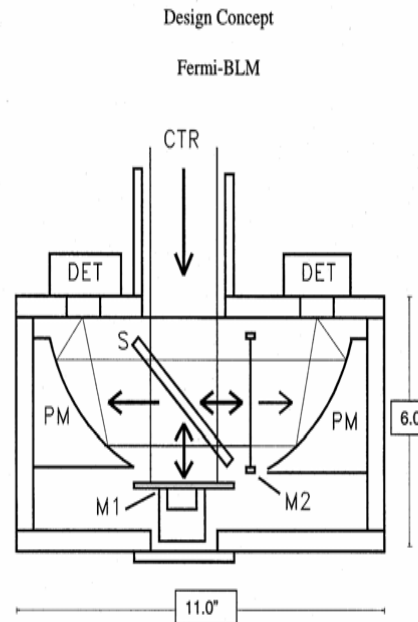
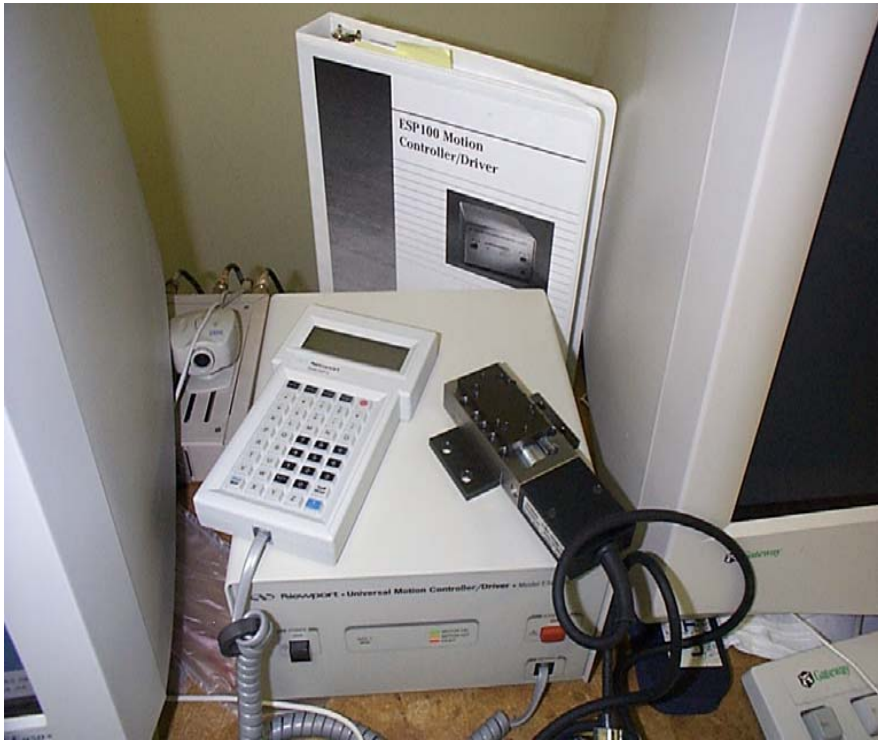


Figure 1

CTR: Coherent Transition Radiation  
S: Beamsplitter  
M1: Mirror on Translation Stage  
M2: Fixed Mirror, Semi-Transparent  
PM: Off-Axis Parabolic Mirror  
DET: Detector Module

Purpose:  
detectors use an  
inverse Fourier  
transform to reflect  
shape of electron  
distribution in bunch

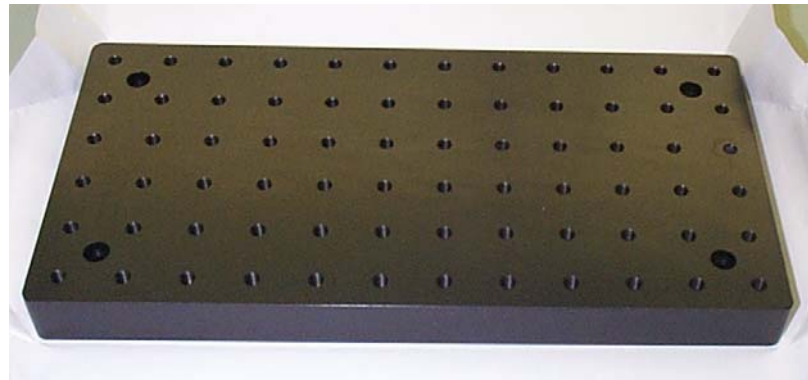
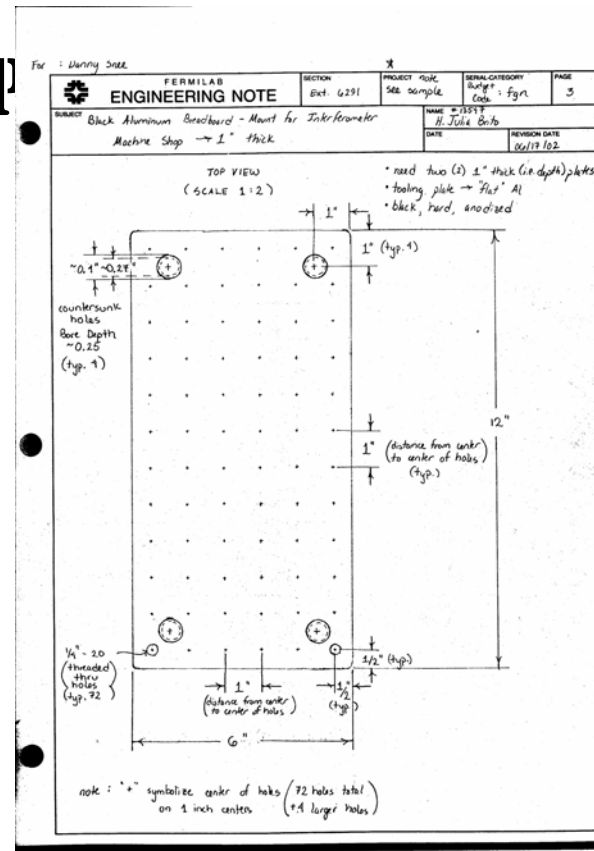
# TRANSLATION STAGE



- Controller/keypad/motor stage system
- Communicate with manufacturers for correct setup
- Labview interface

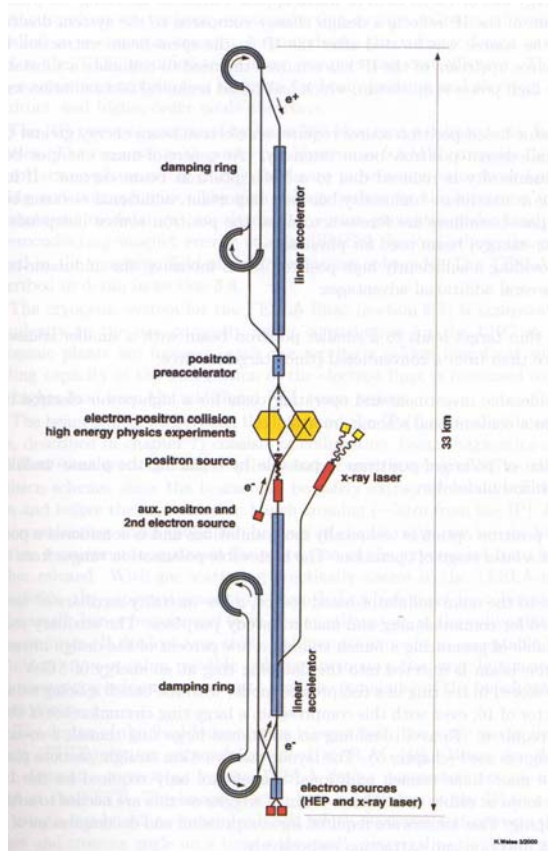
# STABLE P

- Drawing
- Machining
- Polishing
- Packaging
- Shipping



# FUTURE GOALS...

...of A-Zero Photoinjector Lab



...of a little Texan intern



Biomedical Optics,  
Cell/Tissue Engineering,  
Nanotechnology,  
Biomedical Instrumentation,  
Prosthetic Engineering, etc.